Remarks

Matters of Formality:

The examiner rejected claim 11 stating that the limitation "said predetermined angle being repeatable within less than +/- 0.5° at the core region" is a functional result that does not have any support by the relevant proceeding steps and it is not clear how this step is being implemented. The examiner concludes that there is insufficient antecedent basis for this limitation in the claim.

In response, applicants submit respectfully that claim 11 is definite and that the examiner's rejection under 35 U.S.C. §112 is improper. Specifically, the examiner seems to be indicating that cutting precision must be essentially enabled by other elements of the claim. This does not appear to be a proper application of the statute as it confuses enablement with definiteness. That is, the examiner indicates that the claim does not provide a basis for implementing a laser cut with a precision of +/- 0.5°. However, whether the claim provides sufficient disclosure to allow one of ordinary skill in the art to implement a certain precision when cutting is not the issue when assessing definiteness. Under 35 U.S.C. §112, second paragraph, the claims need only specify the metes and bounds of the subject matter which the applicant regards as his invention. This provision contains no requirement that the claim "enable" one to actually practice the claimed subject matter (i.e., in this case, to cut the fiber within a certain precision). The enablement requirement is set forth in the first paragraph of §112 which pertains to the specification–not the claims. Thus, with respect to 112, second paragraph, the issue is not whether the claim provides a basis for implementing a cut of a certain precision, but rather whether one skilled in the art could ascertain the limits of the applicants' method of cutting a fiber within a certain accuracy.

Here, one skilled in the art would have no difficulty in ascertaining the limits of the claim. There is no dispute as to the meaning of "an angle being repeatable within less than +/- 0.5° at the core region." Furthermore, with respect to enablement, the specification

provides a description of a preferred embodiment, that, if followed by one of skill in the art, would result in the claimed precision without undue experimentation. Therefore, Applicants submit that claim 11 meets 35 U.S.C. §112, second paragraph, and the rejection should be withdrawn.

Prior Art Rejections:

The examiner rejected claims 6 and 10 under 35 U.S.C. §102(b) as being anticipated by Kinoshita, et al. (JP354030590A). Specifically, the examiner stated that Kinoshita teaches a process for cutting at least one optical fiber in which a laser device is used to "deliver a beam having a power suitable for sublimating glass . . . and effecting the relative movement of the beam across the glass fiber along a path . . . thereby sublimating the glass 6 and cutting said glass fiber 6 along said path . . . ." The examiner also rejected claims 7, 12, 19, 24-25 under 35 U.S.C. §103(a) as being unpatentable over Kinoshita, et al. In supporting this rejection, the examiner indicates that his comments with respect to claim 6 and 10 apply to these claims as well.

In reply, Applicants respectfully submit that Kinoshita does not teach or suggest the claimed invention.

Claimed Invention

The claimed invention provides an approach for preparing the end face of a fiber which avoids the shortcomings of the prior art by using a laser to cut, shape and polish the end face simultaneously. According to the claimed invention, the fiber is held in a holding and positioning device and the fiber is then cut or machined by means of a laser beam moving relative to the fiber. As a result, a fiber end face can be prepared accurately with a predetermined angle or shape and with surface uniformity such that additional machining of the fiber end face is unnecessary. For example, in a simple configuration, the laser cuts a straight path across the fiber to form a planar end face. The planar end face is preferably angled to the axis such that the end face of the fiber serves to change the direction of the light

exiting or entering the fiber. With respect to this preferred embodiment, since there is no polishing required, the end face may be cut at an angle greater than 15°. It has been found that an end face at such an angle, preferably about 45°, may be used to optically couple the fiber to a device which is not along the fiber's optical path due to its ability to alter the direction of light. Such a light bending technique may be preferable in many optical subassemblies, including, for example, a subassembly comprising a ribbon cable optically coupled to an array of VCSELs in which the vertical operative axes of the VCSELs are perpendicular to the optical axes of the fibers of the ribbon cable.

Laser cleaving also facilitates complex cuts and end face whereas former mechanical systems were relegated to just straight cuts. Since the movement of a laser across the fiber is not limited to simple, straight paths and since no polishing is required, any end geometry is possible with the claimed invention. For example, the fiber end face may be multifaceted or curved to enhance the optical coupling performance of the fiber. A preferred end face shape includes a wedge shape formed by two opposing cuts. In practice, the wedge shaped will tend to be blunted due to surface tension of the softened fiber during cutting. The blunted wedge shape therefore acts a cylinder-type lens at the fiber end. Such a configuration is well suited for optically coupling the fiber with a laser having an elliptical beam.

Aside from the flexibility offered by the approach of the claimed invention in preparing fibers of any desired end face geometry, the laser's sublimation of the glass, rather than a mechanical cut, offers a number of advantages and distinctions over the prior art. For example, ablation of the glass, as opposed to mechanical cleaving, provides for a smooth end face which generally requires little if any subsequent polishing. Furthermore, a laser cut end face tends to have rounded edges rather than sharp edges. This rounding occurs because the fiber material becomes somewhat molten in the vicinity adjacent the cut, and the surface tension of the glass pulls across the edge, thereby causing the edge to flatten or become rounded. On the other hand, the end face of a polished fiber has sharp edges since the fiber does not become fluid during the polishing step to the extent that the surface tension of the fiber material has any significant effect. Such differences in end face geometry are

significant. For example, the rounded edges formed by laser cleaving are better suited for V-groove alignment applications since the rounded edges glide along the V-groove rather than schriving it as a sharp edge might and potentially creating debris in the optical path.

The claimed invention is also able to prepare fiber end faces with unprecedented accuracy and precession. For example, whereas former mechanical systems have typical angle tolerances of greater than +/- 0.5μm, angle tolerances of less than +/-0.5μm can be achieved with the process of the claimed invention. Additionally, the claimed invention offers a high degree of control over the position of the cleaved end face relative to a reference point–e.g., less than +/- 10μm.

Therefore, by cutting an optical fiber using a high-power laser beam in accordance with the claimed invention, advantages in end face shaping and higher precision are realized over traditional mechanical cleave and polish techniques.

Prior Art Reference Kinoshita

Referring to its recently-obtained translation (attached hereto), Kinoshita discloses a method of cutting an optical fiber in which the fiber is heated with a low-power laser and then pulled axially to part it. Purportedly, by focusing a low-power laser (i.e., 0.1 to 5 watts) on a small, "micro" area, the laser causes a rapid thermal gradient which induces significant thermal stress in the area. Once this stress is created, the optical fiber is pulled axially, causing a crack to develop at the maximum point of thermal stress and continue across the fiber such that the fiber parts. Kinoshita purports to achieve excellent results by using a *low-power* C02 laser as the heating source, rather than a high-power laser which melts or evaporates the fiber material. Therefore, a significant aspect of Kinoshita is the use of a low-power laser which creates stresses the fiber, rather than a high power laser which evaporates the fiber material.

Argument

Kinoshita does not disclose a method of cutting an optical fiber by using a high-power laser beam to shape the end face of the fiber. *To the contrary,* there is a clear *teaching away* from using a laser beam to melt or sublimate the fiber to effect cutting. It is well established in patent law that when assessing whether an invention is rendered obvious by the prior art, the prior art must be considered *as a whole* including those aspects that *teach away* from the invention. Here, Kinoshita clearly teaches away from the claimed invention. Specifically, the translation of Kinoshita states as follows:

> [A] method using a laser beam which has conventionally employed is a method of evaporating and removing a portion to be cut by a high-power laser, and is the same as a method of continuously piercing in principle. Accordingly, in the case that this method is applied to cutting of the optical fiber, there are defects that the perpendicularity of the end face is deteriorated and a heat effected layer leaves in the periphery of the cut end surface.

Translation of Kinoshita (p. 4, l. 36-p. 5, l. 8). Kinoshita therefore teaches away from using a high power laser beam to cut and shape the end face of a fiber by stating that a cut made by a high-powered laser beam which evaporates the fiber tends to be unsuitable as it lacks the desired perpendicularity and results in compromised end face attributes.[1] Since Kinoshita teaches away from the claimed invention, it cannot render it obvious. Accordingly, in light of the recently-obtained translation of Kinoshita, the rejection should be withdrawn and the claims allowed.

Allowable Subject Matter:

Applicants gratefully acknowledge the examiner's finding of allowable subject matter in claims 9 and 11. In finding claim 9 allowable, the examiner states that "the prior art of record, taken alone or in combination, fails to disclose or render obvious cutting said glass fiber along said path to shape a wedge on the end face of the fiber in combination with the rest of the limitations of the base claim". Applicants agree with the examiner's assessment of

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[1]It is worthwhile to mention that one way of avoiding these problems, as set forth in the specification, is by pulsing the laser. Pulsing the laser, rather than operating it continuously, limits the energy absorbed by the fiber adjacent the cut and thus minimizes fiber melting.

claim 9 and add that the prior art also does not disclose a laser beam which moves along a path *across* the fiber and has power sufficient to sublimate the glass.

The examiner indicated that claim 11 would be allowable if rewritten to overcome the rejection under 35 U.S.C. §112, second paragraph, described above. At this time, Applicants choose to delay amending this claim until the examiner renders his decision following his reconsideration of this rejection as requested above.

An early and favorable response is earnestly solicited. Thank you.

Respectfully submitted,

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